Understanding Risk to Populations and Infrastructure that are "Crowding the Pacific Rim"

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Crowding the Rim
Fostering collaborative solutions for regional risks

Abstract

Within the last century, natural disasters increased due in part to exploding population and unprecedented urban development. Now as the world becomes more connected, people, information and commodities travel greater distances to service larger populations and urban areas. This global structure necessitates a new paradigm for understanding risk. We propose a model using public domain data and GIS software accessible to planners comprised of 1) a comparative index of five natural hazards, 2) population density, 3) an infrastructure proxy, 4) a vulnerability indicator for the elements at risk (2 & 3) and 5) an interconnectivity index representing the connected nature of a 'globalized' world. We depict this relationship with the equation,

Risk = **H**azard x **E**lements at Risk x **V**ulnerability x **I**nterconnectivity

Because population distribution differs from infrastructure distribution, two contrasting risk representations emerge from this study. Each contrasting assessment reflects the potential for disasters with different types of repercussions, either huge losses of life or those involving large economic losses.

The Problems

- Growing population, urbanization and infrastructure
- Expanding social and economic connections
  - --> Natural Disasters AMPLIFIED by increased population, infrastructure, urbanization and connections

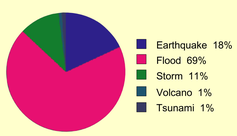
Methods

- Model two types of disaster risk to human life and economic infrastructure using public domain data and the equation Risk = Hazard x Elements at Risk x Vulnerability
- Risk (R) = Create two multi-hazard maps (one for population and one for an infrastructure proxy), two elements at risk maps, a vulnerability map and two final risk maps
- Hazard (H) = Weight each natural hazard by historical fatalities or economic destruction
- Elements at Risk (E) = Assess elements at risk map using population density for the population risk map and Lights at Night as a proxy for the infrastructure risk map
- Vulnerability (V) = Create vulnerability map with the variables Age Dependency Ratio, Male and Female Illiteracy Rates, Gross Domestic Product per capita, Telephone Mainlines per thousand and Physicians per thousand

Multi-hazard Maps

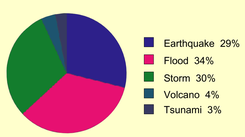
- We assessed 5 natural hazard types: Earthquakes, Floods, Tropical Storms, Volcanoes and Tsunamis
- Each hazard was modeled and relatively indexed independent of other hazards
- Two final hazard maps were created by weighting each hazard type according to (1) percentage of fatalities for the population risk assessment and (2) percentage of economic destruction for the infrastructure risk assessment (see charts below)

Percentage Distribution of Fatalities by Selected Hazard



Source: Center for Research on the Epidemiology of Disasters

Percentage Distribution of Economic Loss by Selected Hazard



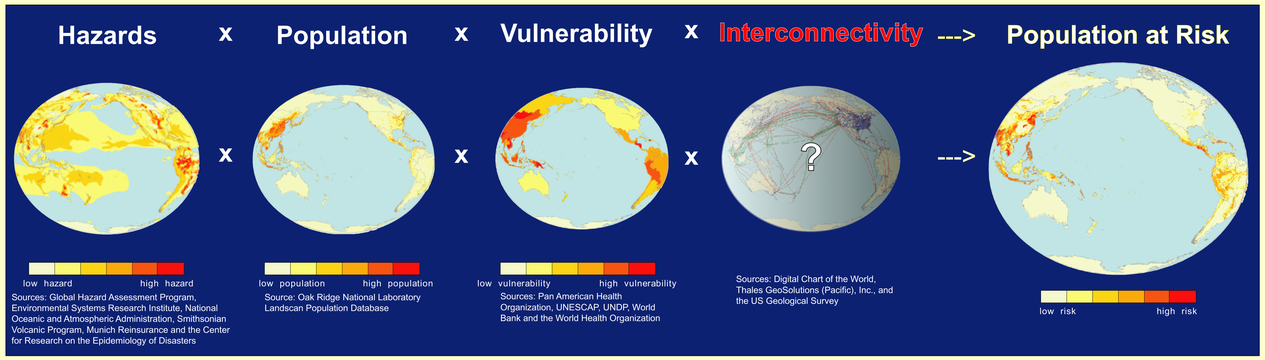
Source: Munich Reinsurance

Risk Model

This GIS model estimates risk (R) using the relationship:

H x E x V x I* ---> R

Where, H is a combined relative index of hazard probability for earthquake, flood, tropical storm, tsunami, and volcanic hazard. E represents a relative index of two independently assessed elements at risk: population and an infrastructure proxy. V, vulnerability, is a relative index of the likelihood and degree of damage to the elements at risk and includes age, health, income, information dissemination and education. I represents the connections between different locations.

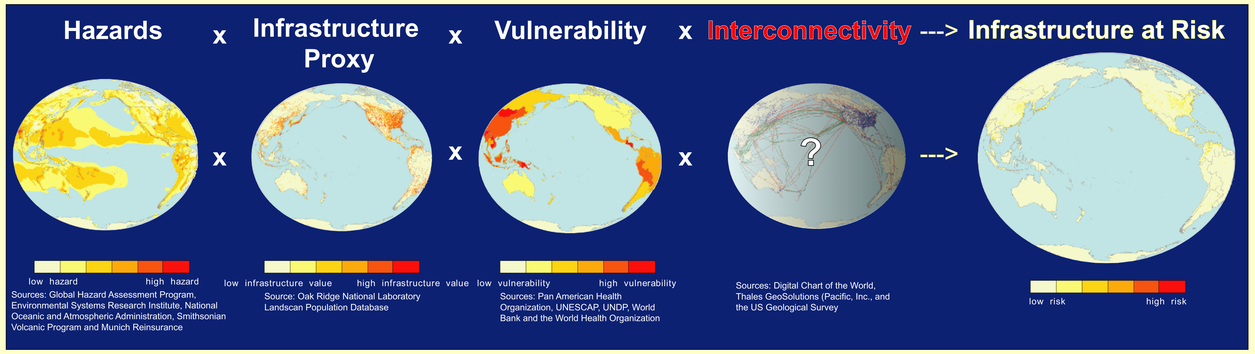


Sources: Global Hazard Assessment Program, Environmental Systems Research Institute, National Oceanic and Atmospheric Administration, Smithsonian Volcanic Program, Munich Reinsurance and the Center for Research on the Epidemiology of Disasters

Source: Oak Ridge National Laboratory Landscan Population Database

Sources: Pan American Health Organization, UNESCAP, UNDP, World Bank and the World Health Organization

Sources: Digital Chart of the World, Thales GeoSolutions (Pacific), Inc., and the US Geological Survey



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*Interconnectivity

- The dynamic networks of people, information and commodities in a 'globalized' social and economic system
- 4 major networks: the electronic communication network, the material network, the familial network and the travel network
- Suggestions for modeling interconnectivity? Types of variables?

Model Shortcomings

- Measuring interconnectivity remains elusive
- Global connections are not fully represented by the infrastructure proxy (Lights at Night)
- The infrastructure proxy only measures risk to certain types of infrastructure (e.g. roads and urban areas) and does not display risk to flight paths or underwater telecommunications cables
- Final risk maps show risk to local spaces but not risk to regional connections

Summary Results

- A dichotomy evolves between 'developed' and 'developing' countries in population loss and infrastructure loss due to natural hazards
  - --> Concentrated population in the 'developing' regions will be disproportionately affected by natural disasters
  - --> Major economic nodes and networks will more likely be affected in 'developed' countries
- Public domain data and accessible tools exist to model regional risk
- This study begins to highlight new economic, social and technological connections and the implicit impacts disasters could have on these connections in the future

The intersection of people, urban infrastructure and natural hazards: How will these complex relationships evolve in the future?

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